forest management note

Note No. 24 Northern Forest Research Centre Edmonton, Alberta

SELECTION FOR EASTERN MANITOBA JACK PINE SEED ORCHARDS BASED ON 10-YEAR FAMILY-TEST RESULTS

INTRODUCTION

In the spring of 1982, jack pine (*Pinus banksiana* Lamb.) family-test plantations in eastern Manitoba were measured 10 years after planting. These plantations are part of a jack pine genetic improvement program that was initiated by the Canadian Forestry Service (CFS) to increase the growth rate and merchantable yield from commercial plantations in Manitoba and Saskatchewan (Klein 1982a, b). Establishment of seed orchards using families selected on the basis of this measurement began with grafting in March 1983 and is scheduled to be completed by 1987. Results were also used to select areas where genetically superior wild seed can be collected until the seed orchards produce sufficient seed to meet planting requirements. This note presents measurement results and describes the criteria used for selection.

MATERIALS AND METHODS

The family test consists of four replicated plantations in eastern Manitoba (Fig. 1), all planted in the spring of 1972 with 2-year-old bare-root seedlings at 1.8 x 1.8 m spacing on rapidly drained sandy soils. Each plantation contains plots of the same 209 open-pollinated progenies of trees selected in natural stands in eastern Manitoba, six open-pollinated progenies of western Saskatchewan origin, and one control lot consisting of two nursery seed lots of unspecified southeastern Manitoba origin. Selection was rapid, informal, and based on superior bole quality and satisfactory growth in relation to neighboring trees. The 209 trees from which progenies were obtained are referred to in this report as *seed parent trees*, and grafts from these trees are referred to as *seed parent grafts*.

In the spring of 1982, height and diameter were measured in the family-test plantations, and stem quality was subjectively rated on a scale of 1 (best) to 5 (poorest). Because of the small size of the trees, diameter was measured at 1 m rather than at the customary 1.3-m height. Rather than using fixed criteria, stem quality ratings were assigned by comparing each tree with other trees in the same plantation. An even distribution of trees among ratings was sought, but there was a deficiency of trees rated 1 or 5, and in part of the test there was an excess of trees rated 3. Trees were rated favorably if their main stems were free of moderate to severe crooks or if one limb had become dominant and upright soon after death of the original apex. Trees were rated unfavorably if they had several moderate to severe crooks, if forks resulting from death of the original apex persisted for several years, or if they had strongly ascending branches.

Mean height, diameter, and stem quality ratings were computed for each progeny. In order to rank the progenies for selection, it was necessary to combine the three means for each progeny into one value. A formula for combining trait means is termed the selection index[1], and the result for one progeny is labeled its index score. Procedures have been described for a formal method of constructing a selection index using genetic variances and covariances and economic weights (Hazel 1943). A less formal procedure was used to determine the selection index

[1] The usage is not uniform among forest geneticists.

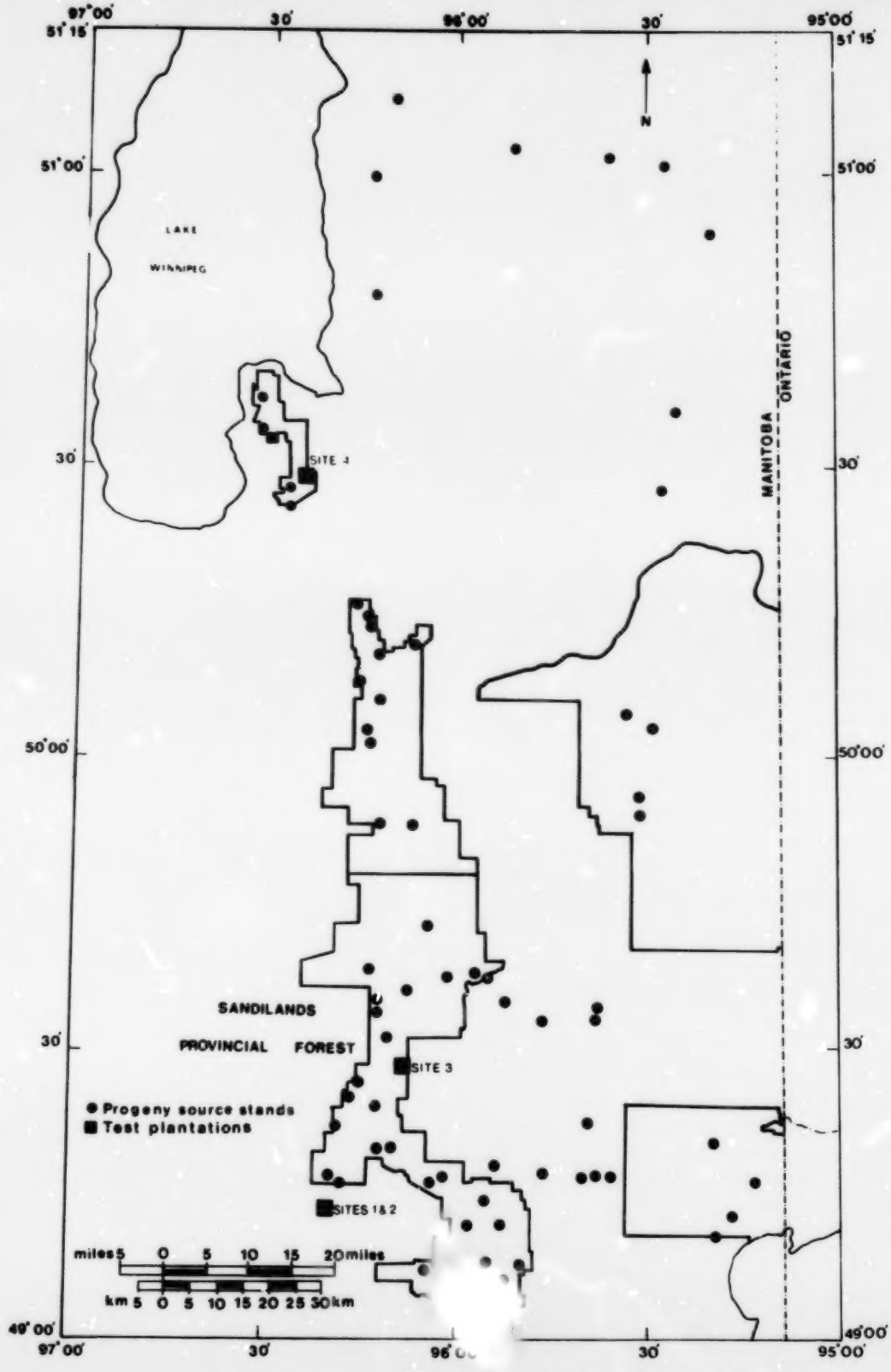

Figure 1. Location of plantations and progeny source stands for jack pine family test.

in this study. The formula was:

$$SIi = \frac{Vi - V.}{SDV} + \frac{Qi - Q.}{3 \times SDQ}$$

where SIi = selection index score for family i,

Vi = mean tree volume of family i, calculated as mean height x (mean diameter/2)^2,

V. = mean tree volume of all eastern Manitoba entries,

SDV = standard deviation of mean tree volume among all eastern Manitoba entries, and

Qi, Q., SDQ = equivalent statistics for stem quality scores.

The ranking of progenies based on this index score was the primary basis for selecting families. A family consists of a progeny together with the progeny's seed parent grafts or grafts of some of its test-plantation trees.

To select source areas for collection of genetically superior wild seed, progeny volume means for each source stand (1-5 means per stand, usually 3) were averaged and the resulting stand means were plotted on the corresponding source locations. Locations with a single progeny were combined with the nearest adjacent source stand. The resulting map was then inspected to identify areas with several adjacent source stands of above-average mean volume. Because each source stand is sampled using a small number of progenies, progeny means for individual source stands are not reliable in predicting the genetic quality of seed collections from their specific locations.

RESULTS AND DISCUSSION

At 10 years from planting, means of the 210 eastern Manitoba entry means (209 progeny means plus one control lot mean) were: height, 250 cm; diameter, 2.85 cm; volume, 514 cm^3; and quality, 2.8. The trees of the Saskatchewan progenies were generally smaller than those of the Manitoba progenies and are not included in any of the comparisons that follow. Of 9573 trees that were alive at 5 years from planting, 8854 (92.5%) were alive and at least 150 cm tall at 10 years. The analyses of variance detected significant variation among progenies for height, diameter, and quality within and across locations.

The selection index scores for the 40 selected families are shown in rank order (Table 1) along with the index score components. The two families ranked lower than 40 were selected to improve source distribution.

The value of the testing and selection procedure depends upon the magnitude of inherent volume and quality superiority of planting stock from seed-orchard seed in comparison to unimproved planting stock in current use. Because planting stock from seed-orchard seed does not yet exist for this program, and no test entry or group of entries can be definitely identified as representative of current stock, the magnitude of improvement in this instance must be estimated indirectly.

Performance means were compared (Table 2) for the select progenies, the control lot, the 210 Manitoba entries, and from among these 210, the 92 progenies that originated from Sandilands Provincial Forest. This last mean was included as an additional basis for comparison because Sandilands Provincial Forest is a major seed source area for eastern Manitoba jack pine planting stock. The performance of the control lot indicated that some current seed lots are genetically inferior to the Sandilands mean in terms of stem volume; therefore, the midpoint between the means for all eastern Manitoba entries and for the Sandilands progenies will be used to represent current stock. The values thus assigned to current stock are 540 cm^3 for volume (average of 514 cm^3 and 567 cm^3 from Table 2) and 2.75 for quality. The difference between the mean of the progeny means for the selected families and the estimated value for current stock is thus 107 cm^3 for volume (647 cm^3 - 540 cm^3) and -0.25 for stem quality (2.5 - 2.75).

The difference between selected and current values is the amount of genetic superiority of average progeny trees of the selected families. Seed-orchard trees will be propagated from seed parent grafts, from grafts of progeny trees superior in height at 5 years to other trees of the same progeny (sibs), and from family-test trees superior to their sibs in volume and stem quality at 10 years. Seed parent grafts of the selected families are genetically identical to the seed parent trees from which they were derived. They are superior to their average progeny trees because their progeny superiority was achieved in spite of pollination by near-average pollen-parent samples (Klein 1982a). Selected progeny trees performed better than their progeny means; therefore, most of them should be genetically above-average among their sibs. The genetic superiority of the seed parent grafts and selected progeny trees to average progeny trees of the same families is postulated to be, on the average, half the superiority of the selected families to current stock (that is, half of 107 cm^3, or 53 cm^3, for volume and half of 0.25, or 0.12, for stem quality). Seed orchard trees, and the planting stock from them, would thus have an inherent mean 10-year volume of 700 cm^3 (540 cm^3 + 107 cm^3 + 53 cm^3) and a mean stem quality rating of 2.4 (2.75 - 0.25 - 0.12 = 2.38). The improvement over current stock would be 30% for volume and 13% for quality.

When source stand volume means are plotted on source stand locations (Figure 2), two areas stand out, both in the Sandilands Provincial Forest. One area has six source

Table 1. Progeny performance of selected families.

Selection index rank	Family number	Mean at 10 yr. Volume (cm^3)	Mean at 10 yr. Stem quality	Selection index score
1	1192	871	2.4	3.91
2	1184	760	2.7	2.49
3	1154	721	2.4	2.43
4	1191	666	2.0	2.34
5	1137	707	2.5	2.18
6	1039	691	2.4	2.14
7	1010	672	2.3	2.06
8	1167	733	2.9	2.00
9	1052	680	2.5	1.92
10	1005	719	2.9	1.86
11	1152	728	3.1	1.72
12	1030	679	2.7	1.69
13	1036	675	2.8	1.54
14	1187	695	3.0	1.52
15	1143	593	2.1	1.51
16	1172	591	2.1	1.49
17	1122	715	3.2	1.49
18	1204	590	2.1	1.48
19	1193	657	2.7	1.48
20	1002	644	2.6	1.45
21	1202	619	2.4	1.43
22	1207	641	2.6	1.43
23	1131	596	2.2	1.43
24	1139	641	2.6	1.42
25	1155	614	2.4	1.39
26	1048	625	2.5	1.38
27	1197	591	2.2	1.38
28	1033	635	2.6	1.37
29	1188	655	2.8	1.32
30	1108	583	2.2	1.30
31	1171	602	2.4	1.26
32	1170	602	2.5	1.16
33	1174	578	2.3	1.14
34	1179	610	2.6	1.12
35	1094	587	2.4	1.12
36	1195	594	2.5	1.08
37	1181	559	2.2	1.06
40	1041	594	2.6	0.96
42	1021	589	2.6	0.92
52	1100	564	2.5	0.78
Mean of 210 eastern Manitoba entries		514	2.8	

Table 2. Genetic gain from family selection and seed orchard establishment based on 10-year family-test results.

Entry or entries	Volume (cm^3)	Quality
Mean of progeny means, selected families	647	2.5
Control lot	417	2.7
210 eastern Manitoba entries	514	2.8
92 Sandilands progenies only	567	2.7
Midpoint between Manitoba entries and Sandilands (estimated value for current stock)	540	2.75
Difference between selected families and current stock = superiority of average of trees selected families	107	−0.25
Postulated within-family gain for seed orchard trees = half of superiority of average trees of selected families	53	−0.12
Total gain (family + within-family)	160	−0.37
% gain = total gain ÷ current stock	29.8	13.4
Seed orchard output values = current stock + total gain	700	2.4

stands north of Sites 1 and 2, with a mean progeny volume of 620 cm^3, and the other area has three source stands near 49° 35' N lat., 96° 15' W long., with a mean progeny volume of 631 cm^3. These volumes represent a gain of about 15% from the postulated base level of 540 cm^3. This gain can be realized immediately by collecting open-pollinated cones from natural jack pine stands in the indicated areas.

SEED ORCHARDS

Establishment of seed orchards using the 40 selected families is under way. The first seed orchard, which will produce part of the total seed required for eastern Manitoba, is located at the Pineland Forest Nursery at Hadashville, Manitoba. This seed orchard is 1.5 ha in size and is laid out in 30 blocks accommodating one graft of each family at 3 x 3 m spacing. Some grafts were planted in the summer of 1983, and grafting and planting are scheduled to be completed in 1985. In the absence of published data a target has been set, based on indirect evidence and unreported observations, to achieve an output rate of 200 viable seeds per year per tree by 1995, about 240 000 seeds per year.

Arrangements have not been finalized for a seed orchard that will produce the remainder of the jack pine seed requirement for eastern Manitoba. Approval is being sought for development of a seed orchard center at the CFS nursery property near Oakbank, northeast of Winnipeg. The proposal includes a greenhouse, intensive site development for the seed orchard, and staffing. Propagation of trees might be done in 1984 by controlled pollination of family-test trees selected within each selected family for superior stem volume and quality at 10 years from planting.

BEYOND THE 10-YEAR SEED ORCHARDS

Remeasurements of the family test at 5-year intervals will be made until the value of further measurements no longer justifies the costs of maintaining and measuring the plantations. Analysis of each successive measurement will be used to score and rank families and individual trees for selection. Additional seed orchard areas may be established following selection if the new selections are sufficiently superior to the trees in the previous seed orchard. A second generation of improvement will be initiated by controlled mating among the genetically best grafts and family-test trees.

J.I. Klein
November 1983

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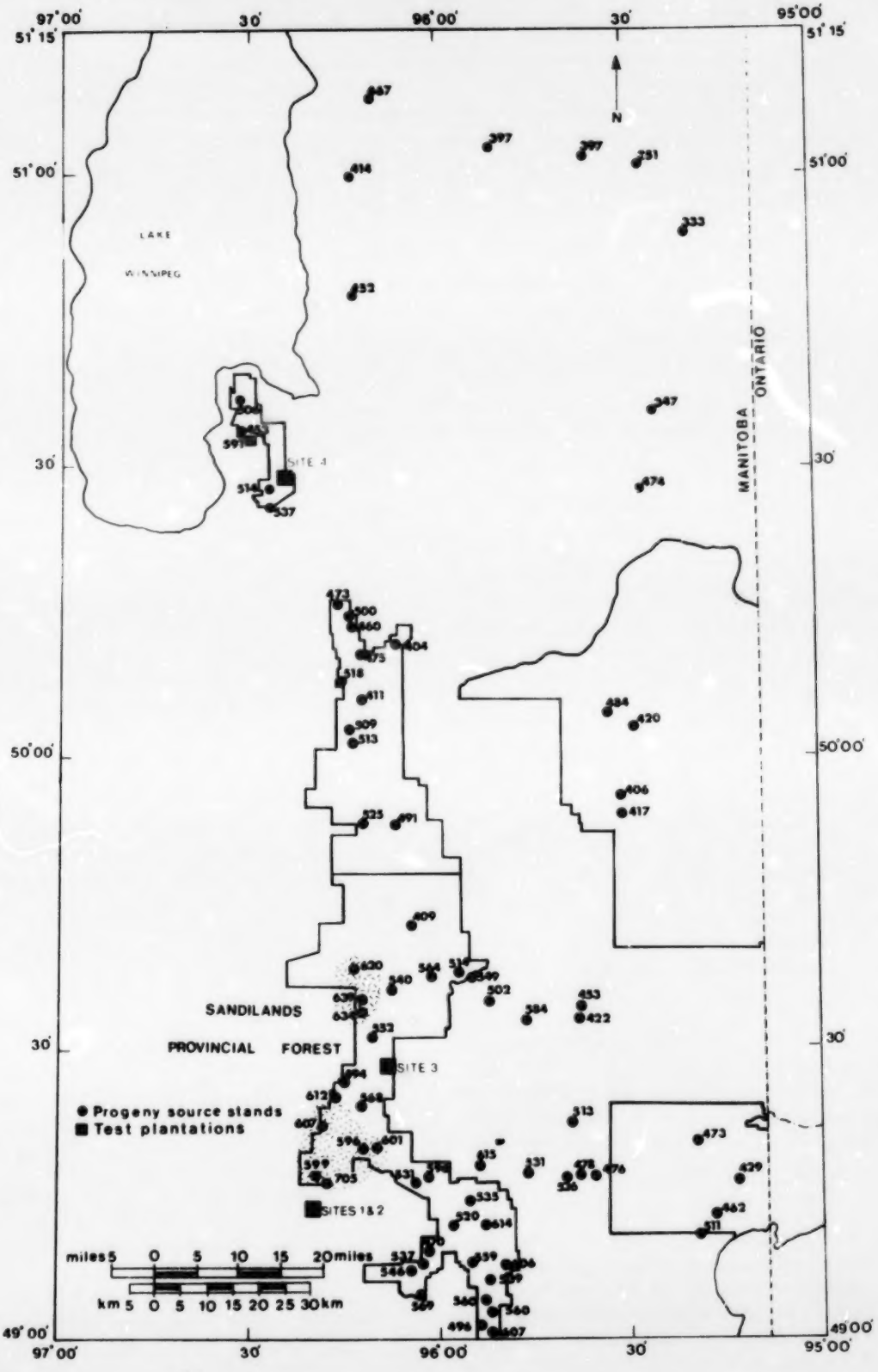

Figure 2. **Mean progeny volume in cm^3 for source stands at 10 years from planting. Shaded areas are recommended for seed collection.**

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